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Biochar: Production, Characterization and Applications

Proceedings

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# Biochar quality management

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# Biochar Quality Management

Biochar: Production, Characterization and Applications
ECI Conference

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# Motivation
## Sustainable Feedstocks

Limits of sustainable utilization

Biogenic residues

Organic waste[1]
4 Mio. Mg/a

Garden and park waste[2]
4.5 Mio. Mg/a

Straw[3]
8 - 13 Mio. Mg/a

Hay[4]
0.6 – 0.9 Mio. Mg/a

Sewage sludge[5]
1.9 Mio. Mg/a (TS)

Sources: [1] UBA, 2011 [2]Destatis 2010 [3]Zeller et al., 2011; [4]Simon et al., 2008; [5]UBA, 2012




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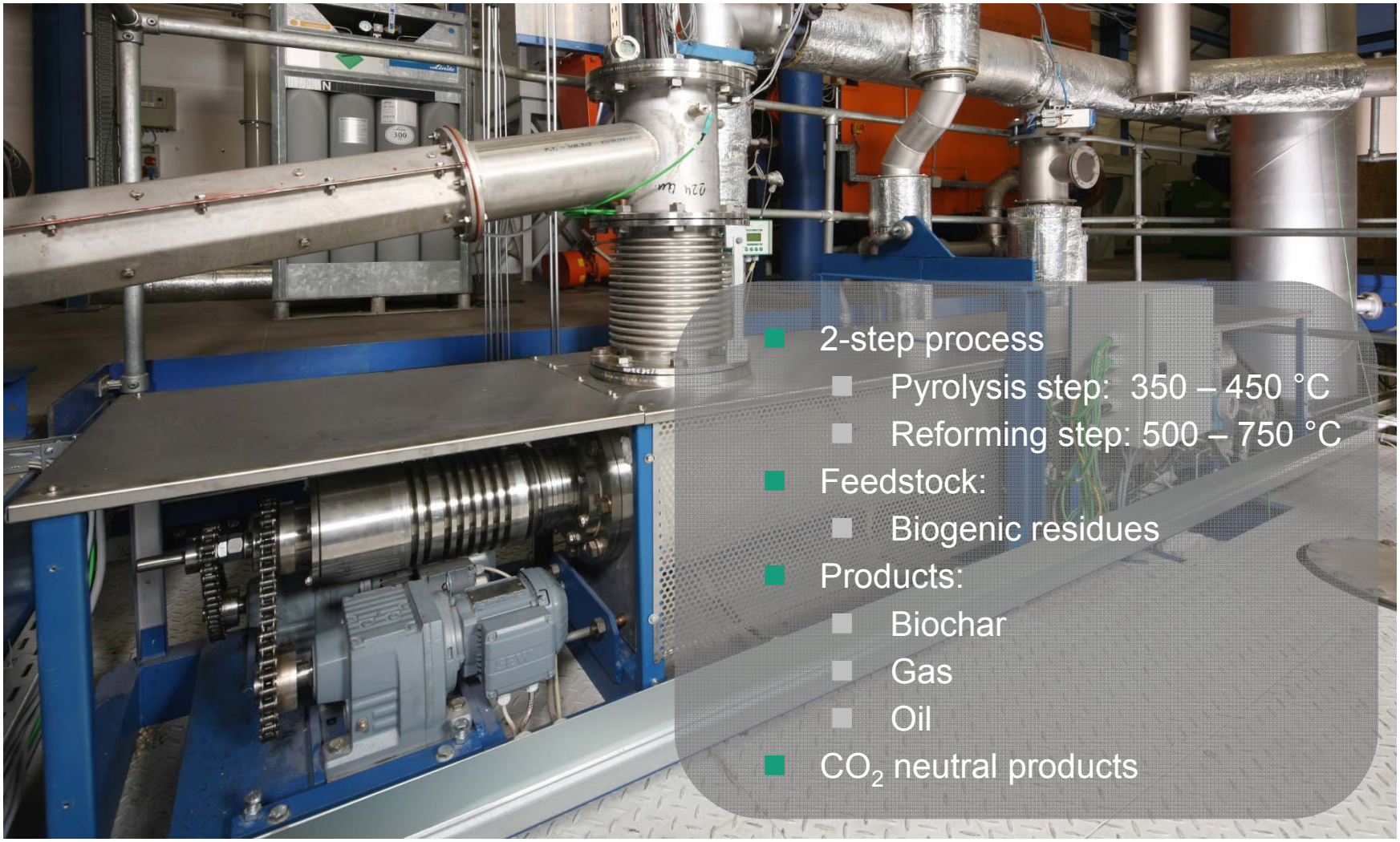
# Production of Biochar

## Thermo-Catalytic Reforming (TCR®)



- 2-step process
  - Pyrolysis step: 350 – 450 °C
  - Reforming step: 500 – 750 °C
- Feedstock:
  - Biogenic residues
- Products:
  - Biochar
  - Gas
  - Oil
- $CO_2$ neutral products

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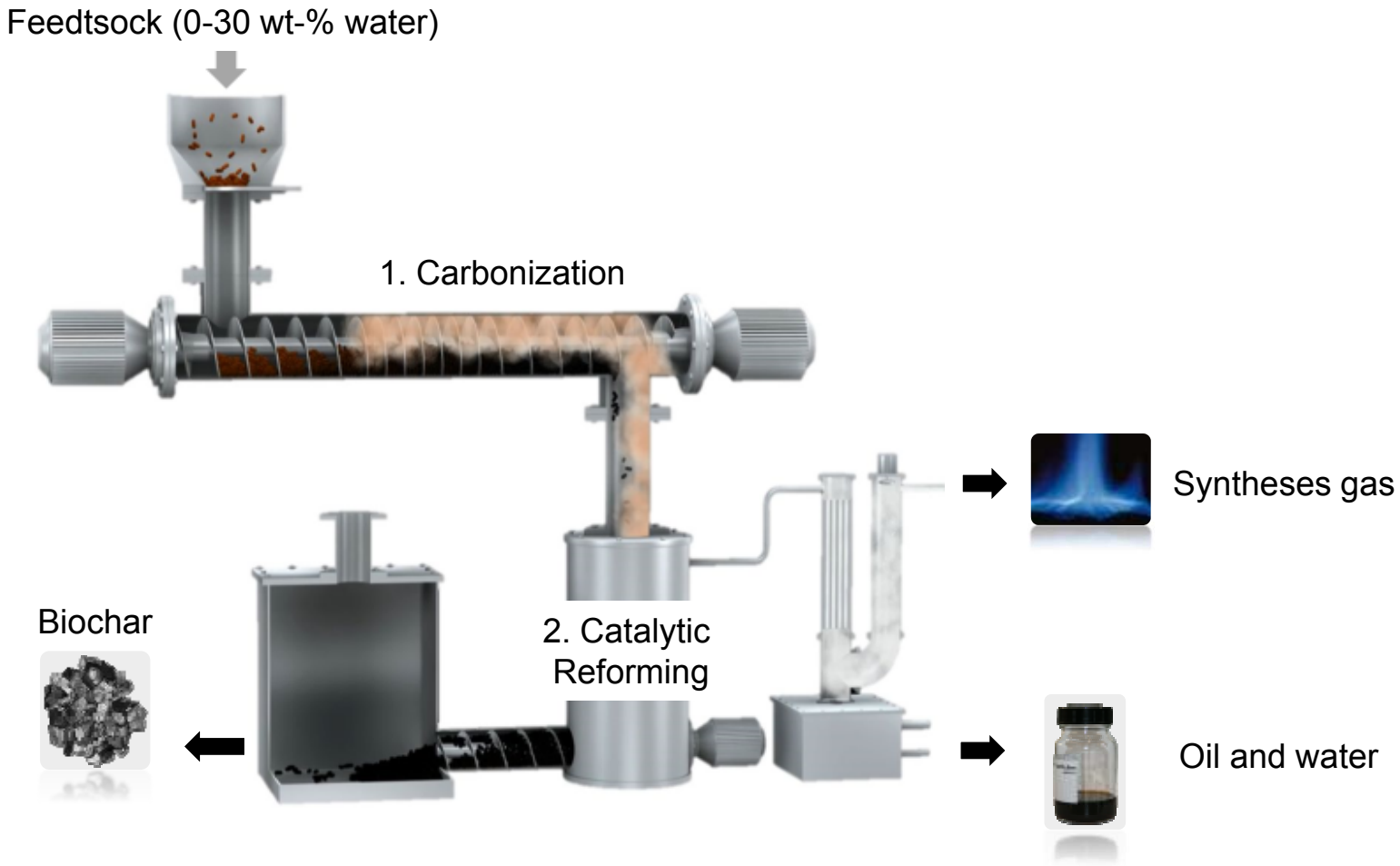
# Production of Biochar
## TCR® process scheme







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# Biochar characterization
## Analysis

| Sewage Sludge | | Digestate | | Brewer Spent Grain | | Wood | |
|---|---|---|---|---|---|---|---|
| **C** | **22.2 wt.-%** | **C** | **64.0 wt.-%** | **C** | **72.6 wt.-%** | **C** | **89.8 wt.-%** |
| H | 0.9 wt.-% | H | 1.0 wt.-% | H | 0.1 wt.-% | H | 2,2 wt.-% |
| N | 2.0 wt.-% | N | 1.4 wt.-% | N | 4.6 wt.-% | N | 0.3 wt.-% |
| S | 1.0 wt.-% | S | 0.5 wt.-% | S | 0.4 wt.-% | S | 0.1 wt.-% |
| O | 0.0 wt.-% | O | 0.7 wt.-% | O | 4.9 wt.-% | O | 4.5 wt.-% |
| **Ash** | **74.4 wt.-%** | **Ash** | **32.0 wt.-%** | **Ash** | **17.5 wt.-%** | **Ash** | **3.1 wt.-%** |
| LHV 8.2 MJ/kg | | LHV 23.0 MJ/kg | | LHV 26.0 MJ/kg | | LHV 34.4 MJ/kg | |

# Biochar characterization

## Nutrients – char from digestate

Requirements for nutrients in accordance to the German Fertilizer Ordinance (DüMV) and analysis results for char from digestate

| NP Fertilizer | solid | Biochar |
|---|---|---|
| Components | [%] | [%] |
| N | 3 | 1.34 |
| $P_2O_5$ | 5 | 7.34* |
| **NK Fertilizer** | **solid** | **Biochar** |
| Components | [%] | [%] |
| N | 3 | 1.35 |
| $K_2O$ | 5 | 6.27* |
| **PK Fertilizer** | **solid/ from ashes** | **Biochar** |
| Components | [%] | [%] |
| $P_2O_5$ | 5 / 2 | 7.34* |
| $K_2O$ | 5 / 3 | 6.27* |
| **NPK Fertilizer** | **solid / from ashes** | **Biochar** |
| Components | [%] | [%] |
| N | 3 | 1.34 |
| $P_2O_5$ | 5 / 2 | 7.34* |
| $K_2O$ | 5 / 3 | 6.27* |
| **NPK fertilizer on substrate** | | **Biochar** |
| Components | [%] | [%] |
| N | 1 | 1.34 |
| $P_2O_5$ | 1 | 7.34* |
| $K_2O$ | 1 | 6.27* |

*Calculation in accordance to DüMV

- Requirements regarding phosphate and potassium contents are met
- Nitrogen contents for NP and NPK fertilizers must be adjusted
- Nutrients requirements for PK fertilizer are met




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# Canadian Food Inspection Agency (CFIA)

## Vision:

- To excel as a science-based regulator, trusted and respected by Canadians and the international community.

## Mission:

- Dedicated to safeguarding food, animals, and plants, which enhances the health and well-being of Canada's people, environment and economy.

Canadian Food Inspection Agency

Agence canadienne d'inspection des aliments

http://www.inspection.gc.ca/




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# CFIA – Biochar Regulation

- CFIA considers 'Biochar' as a supplement under the Federal Fertilizer Act and requires its registration prior to sale or import into Canada.
- CFIA non-compliance could result in product detention and prosecution.
- For registration of Biochar, applicants must demonstrate that the product is safe with respect to human, animal, plant health and the environment.
- **InnoTech Alberta's** pioneering on Biochar Quality Management / Safety Assessment had led to the debut (1st) approval of Biochar for sale/use in Canada.
- **InnoTech Alberta** has assisted/assisting Air-Terra, Prasino Group, Titan Clean Energy, Fraunhofer-UMSICHT, Susteen Technologies and several other clients with biochar product safety Assessments for CFIA registration.
- For further information/guidance please contact:

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# Safety Concerns Associated with Biochar

***Variability in carbon source material and manufacturing processes warrant regulatory oversight, given resultant variability in composition and potential for hazardous by-products and contaminants***

- **Metals**
- **Dioxins and Furans**
  *Higher level of concern associated with sea-transported wood, biosolids*
- **Polycyclic Aromatic Hydrocarbons (PAHs)**
- **Polychlorinated Biphenyls (PCBs), Hexachlorobenzene (HCB) and Emerging Substances of Concern (ESOCs) (e.g. pharmaceuticals) in biosolids**
- **Treated and/or Contaminated Carbon Sources**
  *e.g. treated railway ties*
- **Undeclared NPK Content of Manure and Biosolids**
  *environmental concerns with over-application*




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# Biochar Safety Assessment – CFIA
## Toxicant Compliance Testing

Maximum permissible heavy metal concentration in bio-solids for land application in Canada and USA

| | Unit | EPA | Ontario | TCR char from digestate |
|---|---|---|---|---|
| Arsenic | mg/kg DM | 75 | 170 | < 0.3 |
| Cadmium | mg/kg DM | 85 | 34 | < 0.005 |
| Chromium (total) | mg/kg DM | 3000 | 2800 | 18 |
| Copper | mg/kg DM | 4300 | 1700 | 101 |
| Lead | mg/kg DM | 840 | 1100 | 2.74 |
| Mercury | mg/kg DM | 57 | 11 | 0.017 |
| Molybdenium | mg/kg DM | 75 | 20 | 6.44 |
| Nickel | mg/kg DM | 420 | 420 | 12.1 |

< below the detection limit

Limit values for organic pollutants in biochar in accordance to the IBI guidelines

| | **Unit** | **IBI** | **TCR char from digestate** |
|---|---|---|---|
| PAH | mg/kg DM | 20 | 0.41 |
| Dioxins | ng/kg DM | 9 | < 1.8 |
| Furans | ng/kg DM | 9 | 8.1 |
| PCB | mg/kg DM | 0.5 | 0.001 |

< below the detection limit




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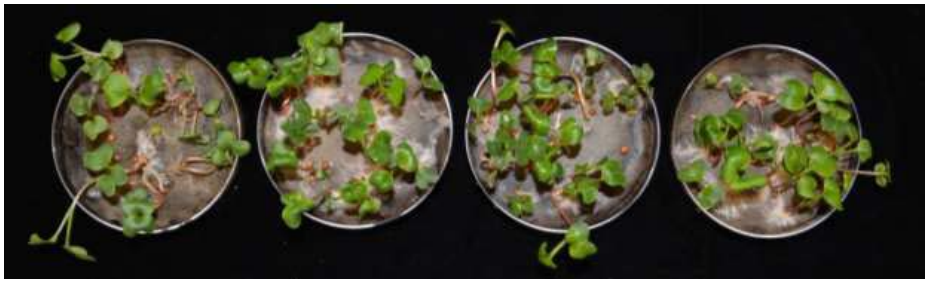
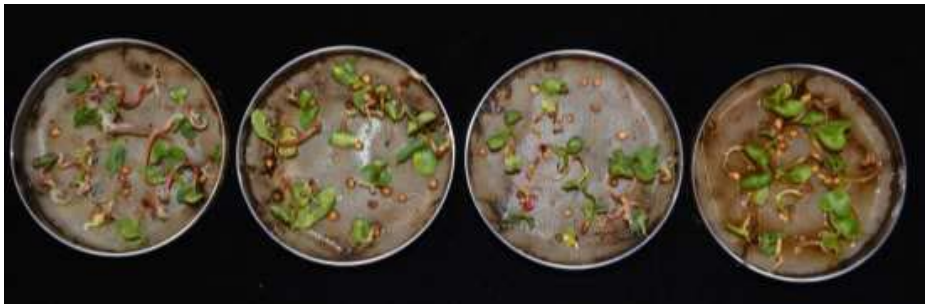
# Biochar Safety Assessment – CFIA

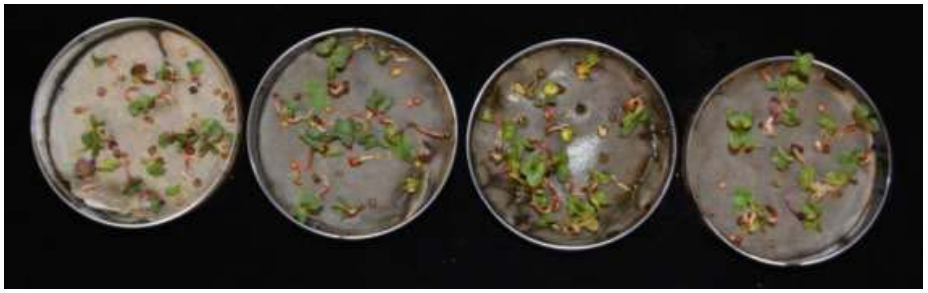
## Toxicity Bioassay - Radish Seed Germination Compliance Tests



- Mixture of peat and biochar (25 wt-%)



- Mixture of compost and biochar (25 wt-%)



- Mixture of soil and biochar (25 wt-%)

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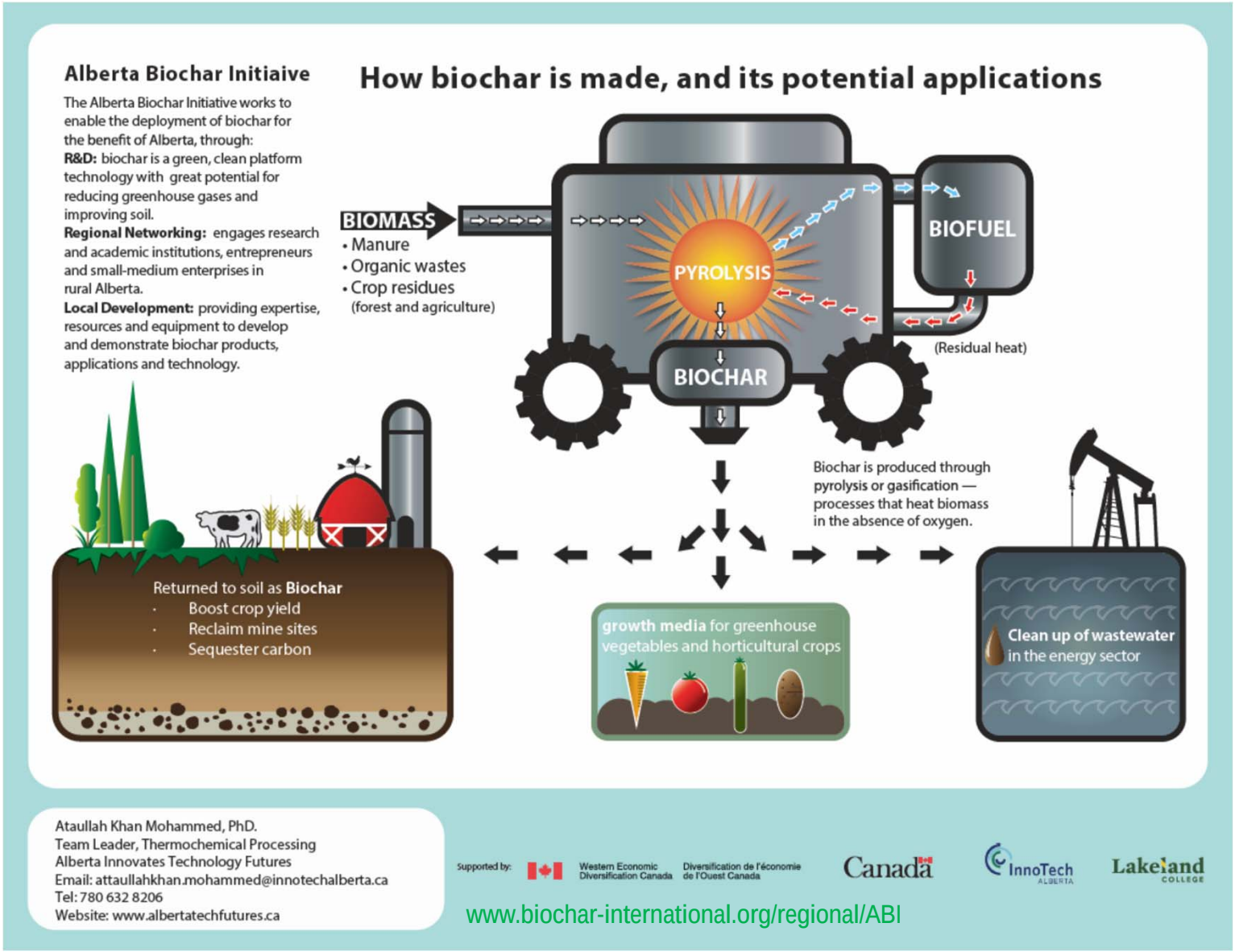
# Alberta Biochar Initiative (ABI)







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# Biochar application
## Energetical use

### Co-incineration in power plants

- Coal-fired power plant
- Biomass heated power plant
- Waste-to-energy plant

### Lime and cement production

- Green secondary fuel

### Small scale combustion plants

- Production of tailor made fuels

### Home area

- Substitute for conventional wood made barbeque coal

Hans-Peter Schmidt 2013




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# Biochar application
## Material use

### Livestock farming

- Additive for fodder
- Livestock bedding
- Manure treatment

### Filter material / Water treatment

- Treatment of drinking water and water for aquacultures
- Exhaust air treatment

### Soil ammendement

- Multi-nutrients carrier
- Additive for compost
- Adsorption of heavy metals or organic pollutants
- $CO_2$-Sequestration

### Metallurgical processes

- Reducing agent
- Slag forming material
- Elektrode material

Hans-Peter Schmidt 2013




Fraunhofer UMSICHT

# BIOCHAR QUALITY MANAGEMENT

## Thank you very much!


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